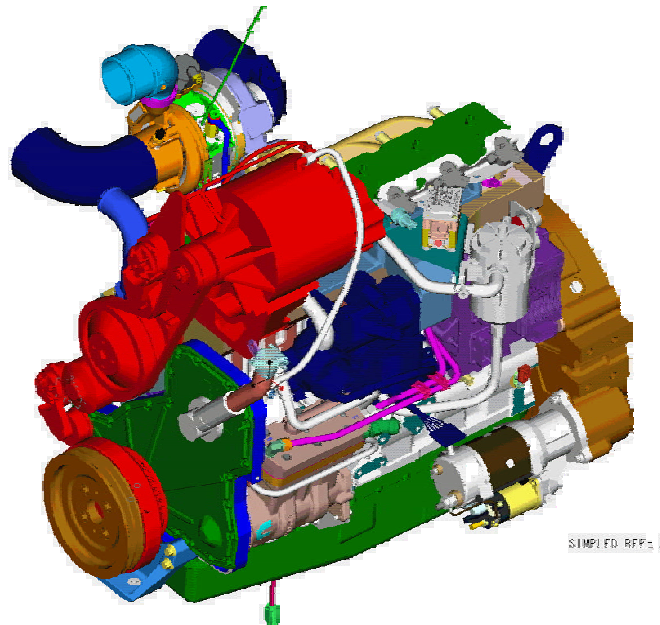


Development of a Cummins ISL Engine at 1.8g NO_x Using Plus Technology

Contract # DE-AC36-99GO10337



Agenda

- Program Overview
- Program Schedule
- Design Highlights
- Development Status
- Summary

Program Overview

- L Gas Plus
 - 8.9 L displacement
- Top rating at launch
 - 320 HP @2300 rpm
 - 950 ft.lb @1400 rpm
- Emissions certification
 - EPA and CARB at 1.8 NOx (gm/hp.hr)
- Launch date: June 30, 2004

Program Schedule

L Gas Development Schedule

			Months																	
Task #	Deliverable #	MILESTONE NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3.1		Completion of Laboratory Development																		
3.1	1	Concept Demo				P														
3.1	2	Design Freeze						P												
3.1	3	Performance & Emissions Capability Demonstrated							P											
3.1		Production Software available											P							
3.1	4	Final Performance & Software Completed												P						
3.1	5	Mechanical Development Completed														P				
3.2		On-Road Prototype Engine Development in Vehicles																		
3.2		Field Test Software available							P											
3.2		Engineering Vehicle Tests Start								P										
3.2	6	Field Test Engines Available									P									
3.2	7	Fied Test Evaluation Completed																P		
3.3		Perform FTP Testing/Commercialize Engine																		
3.3	8	Certification Test Completed															P			
3.3	9	Production Readiness Completed																	P	
3.3	10	Limited Production																		P

P = Plan, F= Forecast, A= Actual

Design Highlights

- More swept volume
 - More power and torque
- New cylinder block
 - Commonality
 - Improved cam follower design
 - Directed piston cooling
- New ignition system
 - Lower cost & improved performance and reliability
- Improved ECM
 - Increased I/O and improved diagnostics
- VGT
 - Low end torque and altitude capability

Development Status

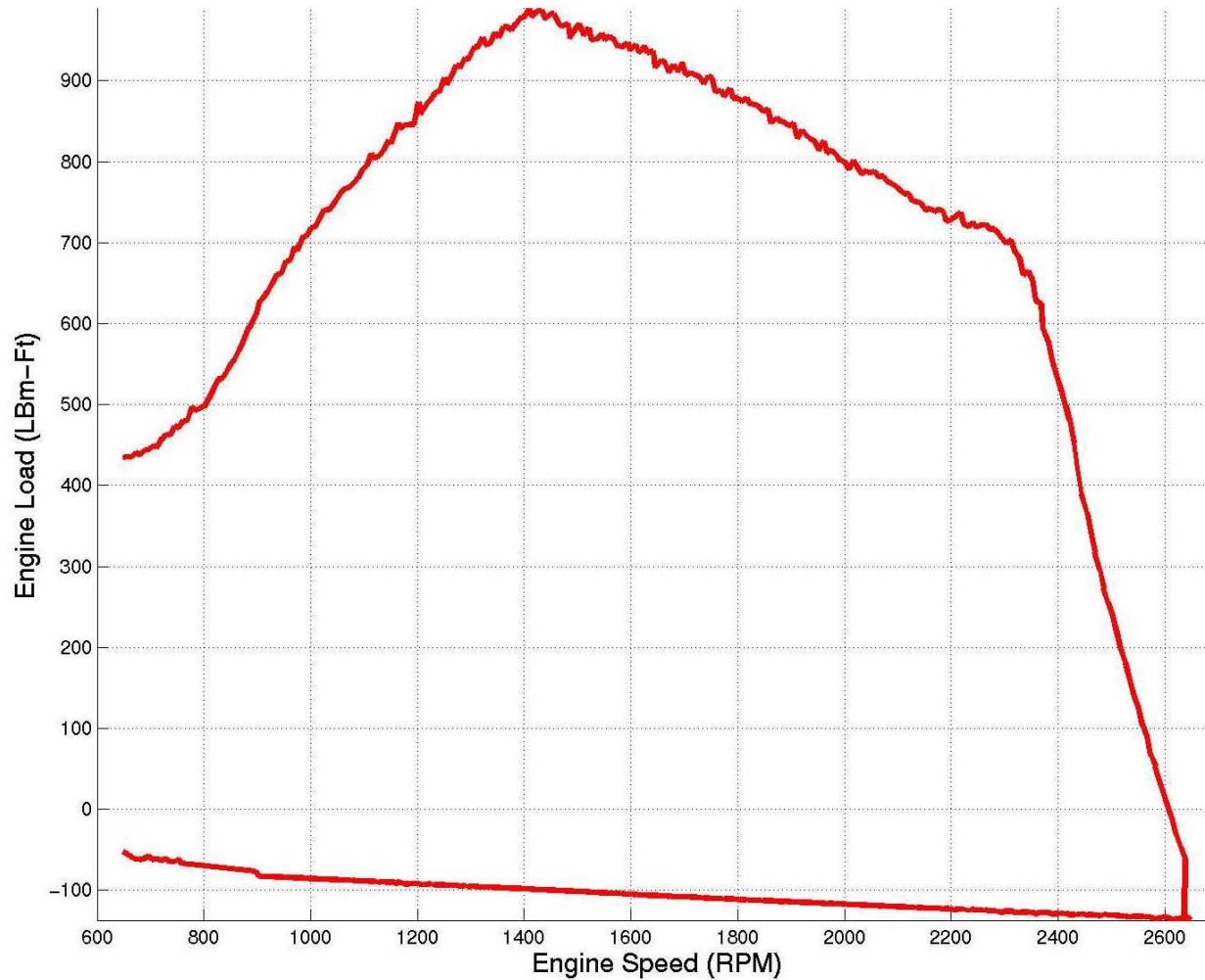
- NREL funding contract is in place
- Concept engine has demonstrated the target rating
 - 320 HP and 1000 ft.lb peak torque
 - Peak torque increased from contract deliverable of 950 ft.lb due to customer needs
 - Deliverable #1 is completed

Development Status

			Months																	
Task #	Deliverable #	MILESTONE NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3.1		Completion of Laboratory Development																		
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3.2	7	Fied Test Evaluation Completed																P		
3.3		Perform FTP Testing/Commercialize Engine																		
3.3	8	Certification Test Completed															P			
3.3	9	Production Readiness Completed																	P	
3.3	10	Limited Production																		P

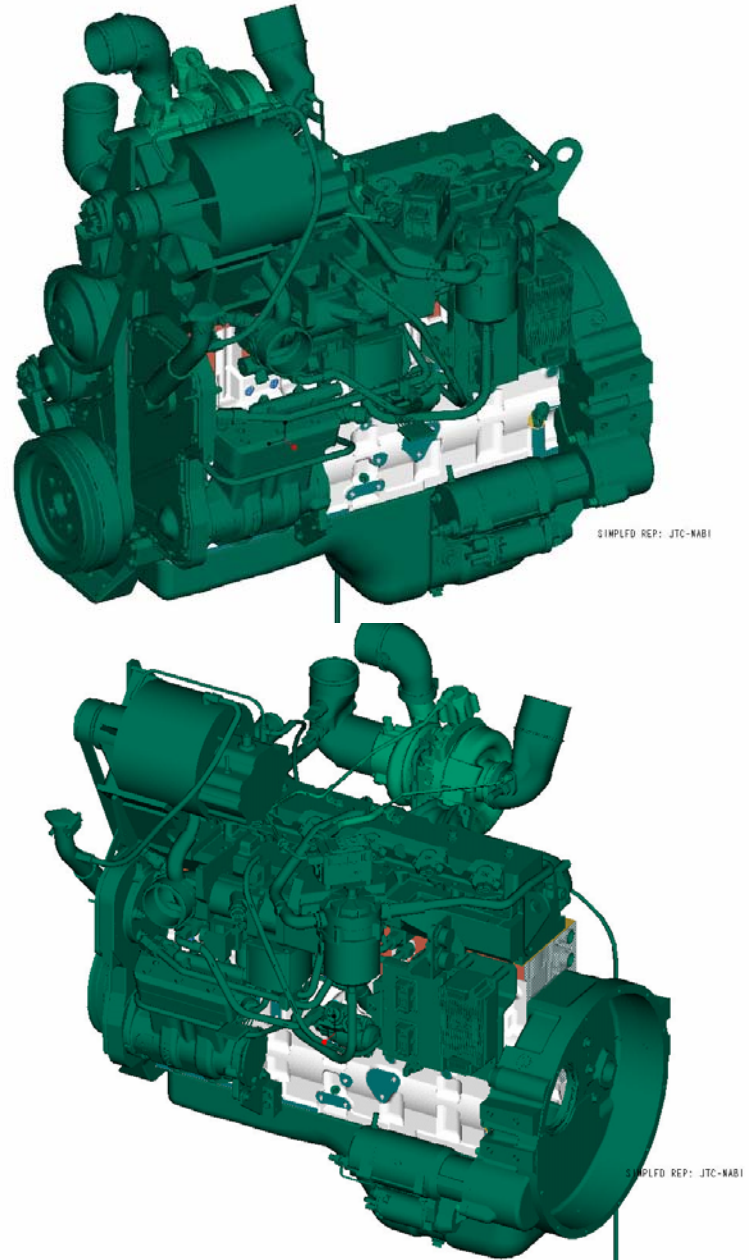
P = Plan, F= Forecast, A= Actual

Torque Curve



Design

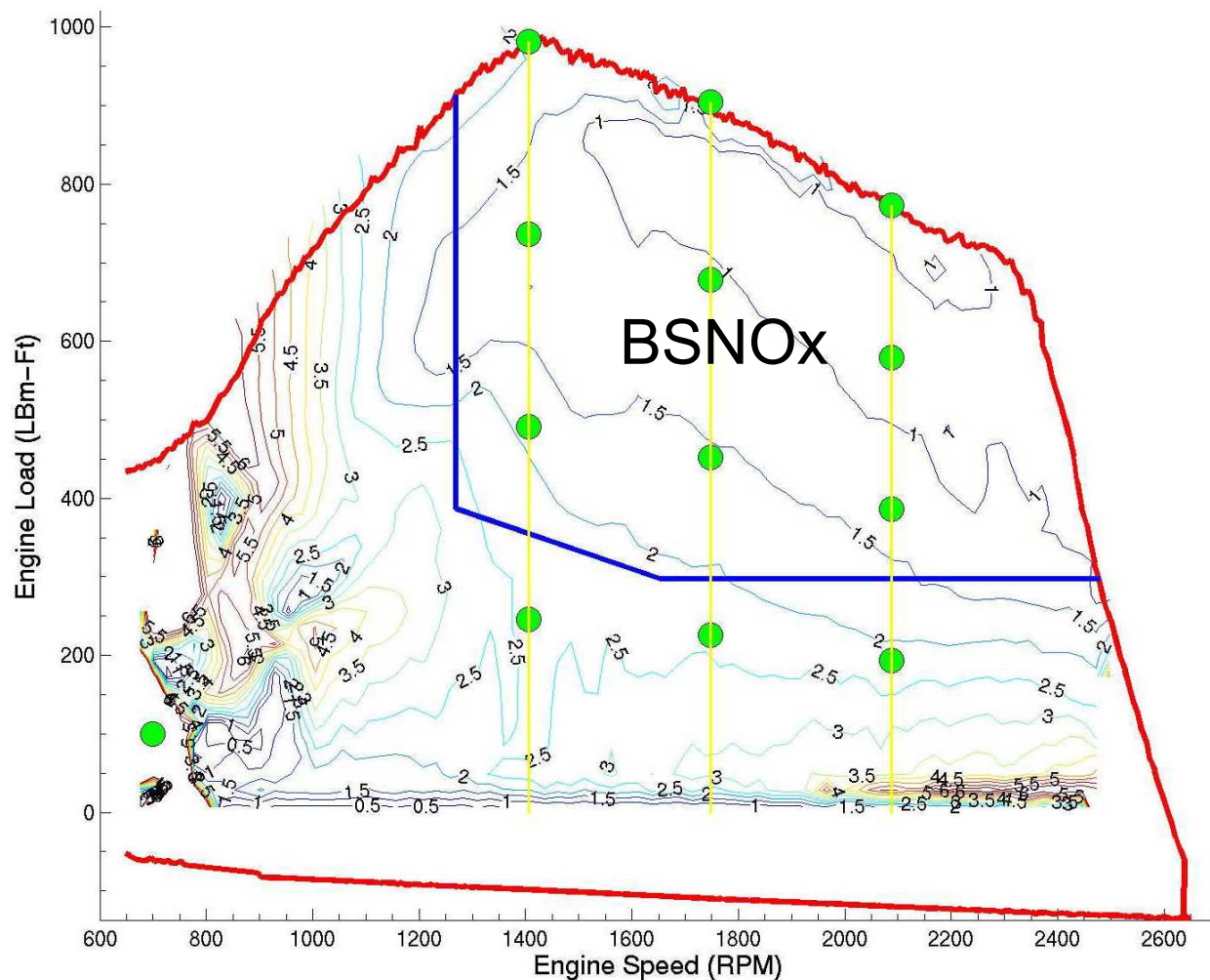
- Concept design is completed
 - Designs available for all subsystems
 - 3 engines have been built; two tested
 - Design review has been completed
- Deliverable #2 is completed



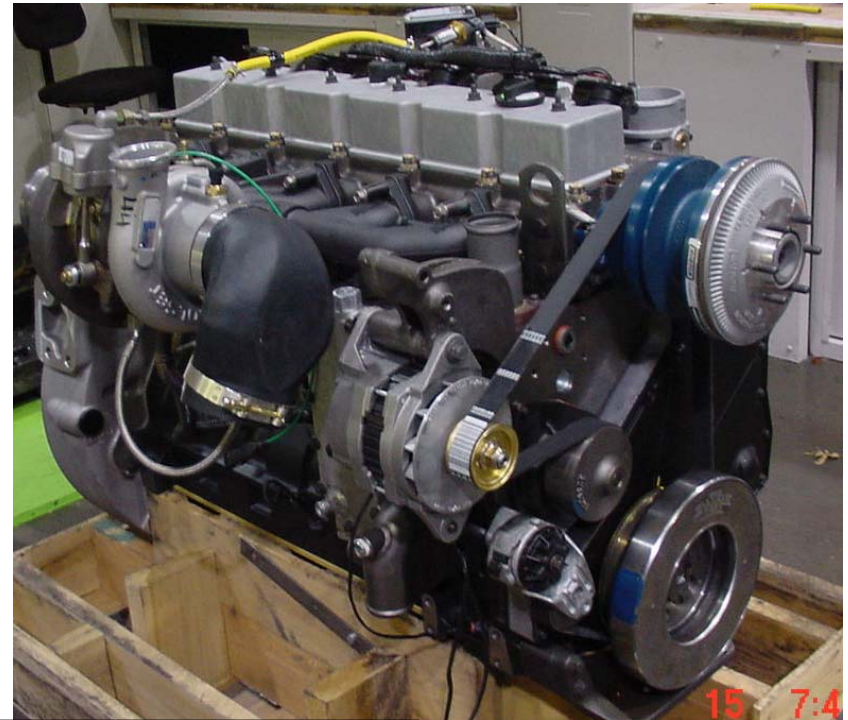
Development Status

- Emissions recipe development underway
 - Demonstrated capability to achieve 1.8 NOx target
 - Facing challenges in combustion stability during ultra lean operation
 - ignition
 - combustion
 - Deliverable #3 is one month behind schedule
 - Anticipate no issues to achieve target
 - Reaching for lower than NOx target
- The new ignition system is operational
 - System refinements underway

Emissions



Engineering Vehicle



Planned operation in August

Summary

- Program is progressing well
- No issues in achieving the target rating and emissions
- Evaluating reaching lower than target emissions
- CWI is committed to delivering low emissions alternative fuel engines for the Automotive market
 - Lower than standards
 - 2010 levels under evaluation
 - HCNG fuels under review